THE TOXIC EFFECTS OF GASOLINE FUMES

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THIS paper is based upon forty-two cases of gasoline poisoning seen at the Dorchester Street end of the Montreal tunnel, and a few experiments performed upon mice and dogs.

The tunnel consists of a shaft about fifty-five feet deep and about twelve feet square; from the bottom of this the tunnel proper runs a distance of about six hundred and fifty feet, the height being about eight feet, and the width about twelve feet. The ventilating apparatus consisted of a zinc pipe eight inches in diameter carrying air forced in by a fan; also compressed air to run the drills. This latter supplied by far the greater amount of air; and by releasing the air up against the face of the tunnel it forced the gases back to the shaft.

The source of the gasoline fumes was a gasoline motor engine, which was used to draw the cars of rock from the face of the tunnel to the bottom of the shaft. As long as the engine was not running the ventilating apparatus was sufficient to keep the air in the tunnel quite fresh, except for a few minutes after blasting; but within one hour after starting the engine the air would become foul, causing a throbbing and congestion of the vessels of the head and, if continued, headache.

On November 22nd two men were overcome by fumes and carried out of the tunnel. They had been mucking, and suddenly collapsed and became unconscious. I saw them within twenty minutes and they were then beginning to come to. The most notable feature of the cases was the extreme flushing of the face. The pulse was about one hundred to one hundred and eight, of good volume and tension. Respiration was rapid, about thirty-six, and deep. The knee jerk, plantar, and cremasteric reflexes were absent. The conjunctival reflex was present, as was also the pupillary reaction to light. The pupils were moderately dilated. The men were able to move their arms and legs, but not able to speak. There was also slight salivation. The men rapidly regained consciousness, and complained of very severe headache, chiefly in the frontal region. They returned to work in about an hour. There was no nausea or vomiting. Next day they felt none the worse for their experience.

On November 24th sixteen men suddenly collapsed within a few minutes of one another and without giving any warning of their condition. Those that were working with their heads low seemed to be most effected. The men were all brought to the surface as quickly as possible and I saw them within twenty minutes of the occurrence. They were in all stages of anæsthesia. Some had only muscular weakness, headache, and salivation, having recovered consciousness before I arrived. Others were struggling and shouting as in the second stage of ether anæsthesia; but not understanding anything that was said to them, nor had they any recollection afterwards of what had occurred once they had become unconscious. A few were absolutely unconscious, with perfect muscular relaxations, feeling nothing when a pin was stuck into their skin; a couple, besides being perfectly anæsthetized, had clonic spasms of arms and legs, coming on every few minutes and lasting a minute or so at a time.

The following conditions were common to them all: suffusion of their faces and hands; absence of most reflexes, except in those who had recovered consciousness; presence of conjunctival and pupillary reflexes; moderate dilatation of the pupils; pulse good, and never over one hundred and ten. Three of them not showing much improvement after one hour were sent to the hospital; but they did not stay there long. They all complained of severe headache on recovering. None had any nausea or vomiting. They did not return to work that day.

Next day, November 25th, the same gang were at work and eighteen men were overcome with the same symptoms. On both these occasions the engine driver was the most affected and took longest to recover.

Samples of blood were taken from the men and examined spectroscopically. These gave the bands for oxyhæmoglobin, and reduced perfectly with ammonium sulphide and with Stoke's solution, showing absence of carbon monoxide. The engine was then stopped and samples of air were taken from the tunnel. The report on these was that they consisted of natural air with traces of gasoline fumes and no carbon monoxide. The tunnel was then aired by pumping in compressed air for three hours, then stopping the pump for two hours to allow for collection of gases from fissures in the rock, and then another set of samples was taken. The report here was pure air. A dozen white rats were then hung in cages in the tunnel at different distances from the shaft and at varying heights from the ground. One died that night. This was the one

nearest the face of the tunnel and near the ground. The engine was then started again for a few hours, and samples of air taken once more. The report on these agreed with the first report.

On November 26th the engine was running and a man was set to watch the mice; and if they showed signs of becoming overcome, the men were to have been withdrawn from the tunnel. However, four men were overcome, whereas the mice were not. The engine was then stopped. But six mice died the following night. These were the mice farthest from the shaft. Post mortems were performed upon these, and their veins were found distended with blood and the right side of the heart very much distended. The blood was examined spectroscopically and only oxyhæmoglobin found.

The ventilating apparatus was then overhauled and repaired, and in addition a suction fan was placed at the bottom of the shaft to carry off the fumes which, being heavier than air, seemed to collect. On December 9th the engine was started again under these new conditions; but within a few hours two men were overcome, one of them to a very marked degree, his pupils being dilated, though the conjunctival and pupillary reflexes were still present. He had marked clonic spasms, and it was about two hours before he showed any signs of returning consciousness. His blood was examined spectroscopically, and showed only oxyhæmoglobin. The engine was then removed from the tunnel, since when there have been no more cases of men being overcome with these symptoms.

EXPERIMENTS. I.—Four rats were used. These were placed in separate bell-jars and a small amount of gasoline was introduced. The following symptoms were noted: First, reddening of noses and gums; secondly, salivation; thirdly, restlessness; and fourthly, muscular relaxation and anæsthesia, coming on in one and a half to two minutes. The conjunctival reflexes were still present. Then came a stage when they had clonic spasms with perfect relaxation between the spasms. The rats were then removed from the gasoline fumes, and recovered in about thirty minutes; but three died without visible cause next day. Post mortem: their livers seemed to be very friable.

II.—Two dogs, small fox terriers. The dogs were put into a very large glass jar, and an ounce of gasoline was introduced into the jar, and the cover put on. The following symptoms were noted in order: reddening of nose, gums, and feet; salivation; restlessness and probable formication, as both dogs at this stage tried to bite their limbs furiously; muscular weakness; sudden gasping, with

perfect relaxation and anæsthesia. The dogs were then removed from the jar and the anæsthesia continued with a cone, as with ether. The anæsthesia was perfect. The conjunctival and pupillary reflexes were present, and sensation absent. The pupils were moderately dilated. The pulse was one hundred and twenty-nine, of good volume and tension; it was one hundred and twenty before anæsthesia started. Respiration was deep and rapid, twenty-six to the minute. Then clonic spasms appeared; and after fifteen minutes anæsthesia, without any warning, the respiration and heart ceased simultaneously; nor could they be made to return by any means.

A post mortem was immediately performed and the following conditions found: the heart had stopped in diastole and the right side was very much dilated. The veins all over the body were markedly distended, including the veins of the brain. There was marked venous congestion of the posterior parts of the lungs, and marked congestion of the liver, which in one dog was very friable. There was no mucus in the trachea.

From these experiments it will be seen that the symptoms in the animals were very similar to those in the men. The following are to be specially noted: the persistence of the conjunctival reflex, which never disappears; the marked venous congestion; the good pulse, which is not very rapid. After the stage of muscular relaxation appears there is a stage of clonic spasms; this I believe to be a danger sign. Absence of vomiting afterwards, and the severe headache following, are to be noted.

Box[1] reports two cases of petrol poisoning. He notes that in one the face was flushed and cyanosed, and that in the other the face was pale. Both had muscular weakness with shivering and spasms, but no vomiting. He notes that the pulse was rather small and fast, in this differing from my cases. They both recovered rapidly when brought into the air. Houghton[2] reports the case of a woman who was washing her hair with petrol in a small bath-room. She was overcome in three minutes. She was pale, the conjunctivæ suffused, pupils dilated; the pulse was thready (ninety), and felt as if shot were propelled beneath the finger. She was also delirious. It was four days before she felt well.

Petrie[3] reports a case of a chauffeur who, while working over a tank of petrol, was overcome and fell into the tank, where he remained for ten minutes exposed to the fumes. His face and hands were blue and he was foaming at the mouth, pulseless, and with eyes open and turned upward. A short time after he was removed

from the fumes he began to fight with his hands and feet, and his pulse gradually returned. He retched, but did not vomit. Later he became violent and tried to bite everybody. Then he complained of headache; but was perfectly well next day.

Dr. Fraser Gurd, in a personal communication, described a case in which he performed a post mortem upon a man who was found dead in a large tank that he had been cleaning with gasoline. Nothing was found but venous congestion.

Sollman[4] in his text-book says that in frogs gasoline causes purely paralytic symptoms. In mammals, when it is largely diluted (one to eight of alcohol), the anæsthesia may be kept up as long as two hours without noticeable bad effects. If carefully handled it produces no changes in blood pressure, pulse, or respiration. It is, however, rather unsafe, even in this concentration, since it produces its toxic effects *very suddenly*. The toxic effects from concentrated gasoline vapour consist primarily in very characteristic convulsions. These are best seen when gasoline is given in strong form without any other anæsthetic. The animal falls on its side, claws the air with all fours as if running, the pupils are widely dilated, the reflexes absent; spasms are intermittent and between them the dog is perfectly limp, except that his toes, tail, and eyelids continue to twitch. The respiration is first stimulated and then weakened. There is paralysis of the vagus, and then depression of the cardiac muscle and later of the vasomotor centre. Either the heart or respiration may stop first.

The following conclusions may be drawn:

Gasoline fumes are dangerous, and the final outcome is very sudden.

Gasoline engines are dangerous in tunnels where the ventilation is not extremely good, and should never be used in tunnels that are entered by means of a shaft.

References:—

1. Box, *Brit. Med. Journ.*, 1908, Vol. i, p. 807.
2. Houghton, *Brit. Med. Journ.*, 1908, Vol. ii, p. 1747.
3. Petrie, *Brit. Med. Journ.*, 1908, Vol. i, p. 987.
4. Sollman, "Text-book of Pharmacology," 1901, p. 445.

Several appointments have been made under the regulations for the new Research Scholarships in the medical department of the University of Toronto. Dr. C. Imrie is Junior Research Fellow; and Dr. Fletcher, Dr. McPhedran, and Dr. R. D. Armour are Senior Research Fellows. Dr. A. H. Caulfeild has also been appointed and will continue his work in tuberculosis, which was so unfortunately interrupted in Gravenhurst last spring.

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